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ABSTRACT

This guide contains lesson plans and outlines of science activities which present concepts of solar energy in the context of biology experiments. Each unit presents an introduction; objectives; skills and knowledge needed; materials; methods; questions; recommendations for further work; and a teacher information sheet. The teacher information sheet provides the target grade level; additional subject areas involved; background information; hints on gathering materials; suggested time allotment; suggested approach; typical results; precautions; modifications; evaluation; and references. (RE)

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DOE/CS-0065

Activities

Biology

ED173161

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SOLAR ENERGY PROJECT

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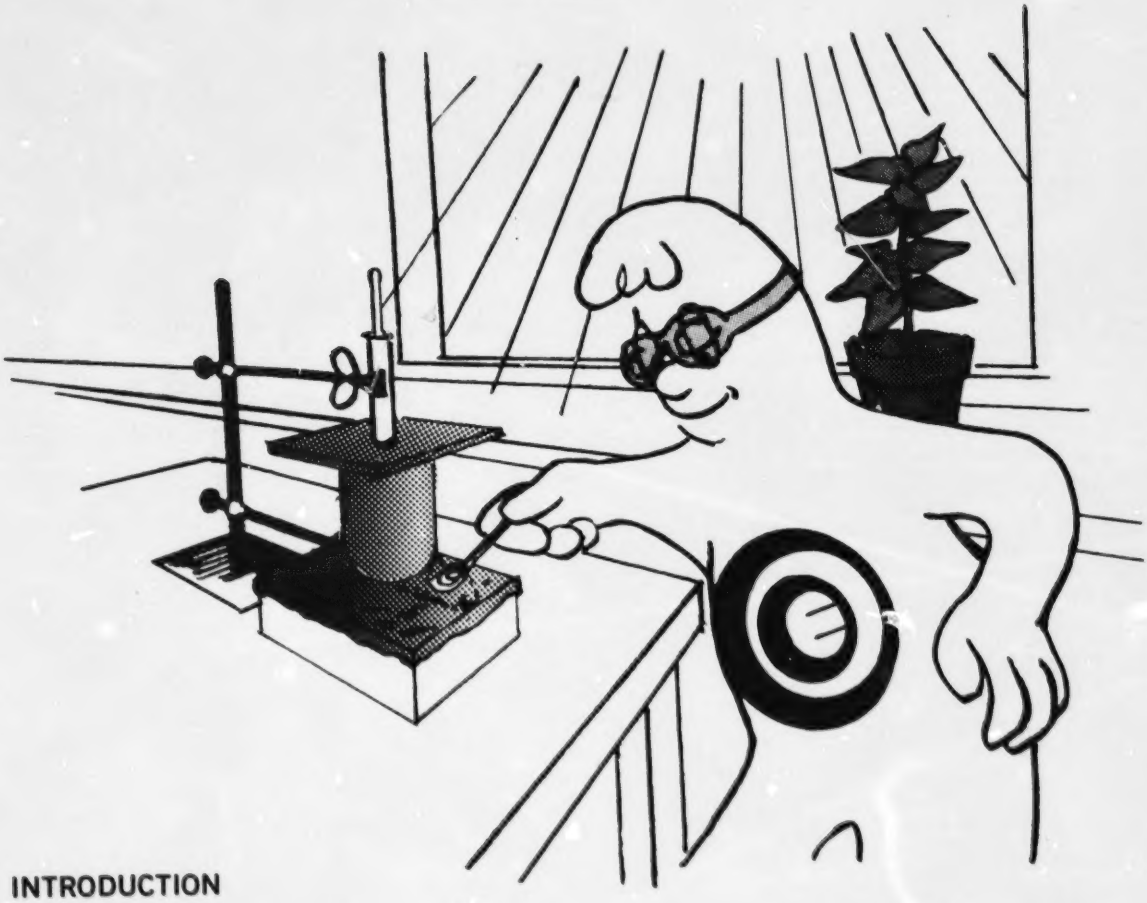
BEANLIGHT



INTRODUCTION

Have you ever thought about the amount of energy used to make plants grow? Plants cover a large portion of the earth's surface and are very good solar collectors. We get back some of the energy stored by plants when we eat our food but much of the plant's energy is wasted.

This activity will show you a way to use some of the solar energy stored in plants to produce heat. Many uses can be found for heat energy. Can you name a few? The name BIOMASS is used to refer to the plant material available to produce energy. In this activity you will experiment with one form of biomass.

OBJECTIVES

At the completion of this activity, you should be able to:

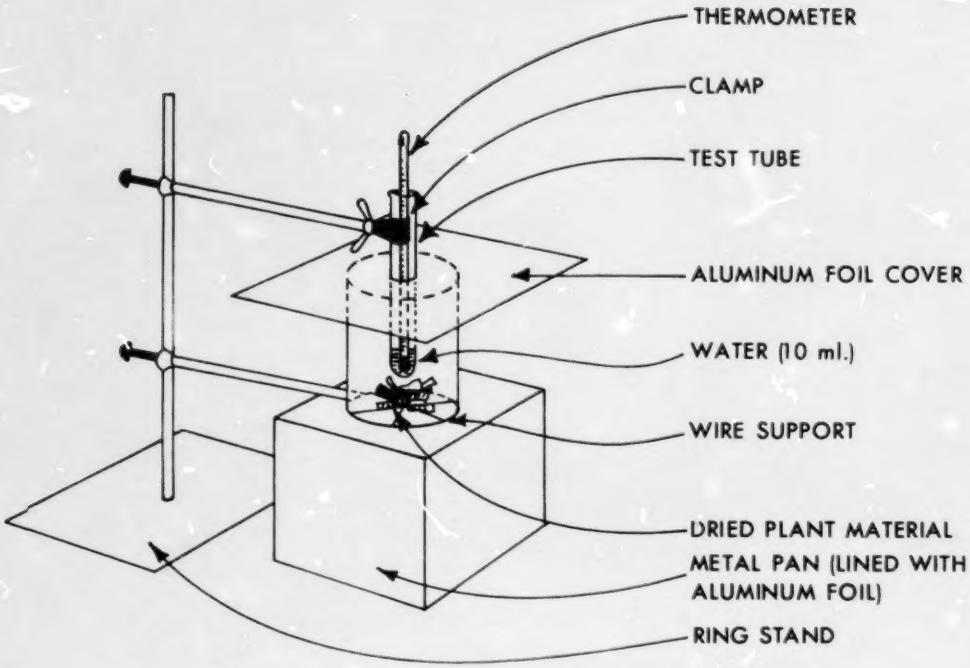
- o grow plants.
- o measure the mass in grams of the dry plant before burning.
- o determine the amount of heat energy released when the plants are burned.

SKILLS AND KNOWLEDGE YOU NEED

- How to dry and prepare plants for burning.
- How to read a thermometer.
- How to determine volume in milliliters.

MATERIALS

- Balance.
- Earthenware pots or cut milk cartons.
- Flower or plant potting soil.
- Bean seeds.
- 50cm of wire.
- A standard lab thermometer (-10°C to 110°C).
- Ringstand.
- Metal can about 8cm in diameter.
- Large test tube.
- Metal pan.
- Aluminum foil.
- Graduate cylinder with a capacity of 10ml.



METHOD

1. Fill the plant growing container with potting soil.

2. Unless otherwise indicated, place the bean seeds in the soil 1cm below the surface and water it well.

3. Place the container in a sunny location. If sunlight is not accessible, assemble a light source which radiates light at a constant rate.

4. Allow the plants to grow about 30 days or to a height of about 45cm.

5. When the plant has reached the desirable height, carefully remove it from the soil and wash the soil from its roots, leaves, and stems.

6. Twist the plant into a "log" shape and wrap with paper toweling. Allow it to dry. The plant should be dry enough to burn in approximately one week. Less time will be needed if a drying oven is available.

7. Remove the plant material from the paper towel and determine its mass in grams using a balance.

8. Place the plant "log" on the wire support at the bottom of the can.

9. Pour 10ml of water into a large test tube that is clamped to the ringstand. This test tube should be lowered into the can so that the test tube is just above the plant mass.

10. Put a thermometer in the test tube and record the water temperature in the data table.

11. Put aluminum foil over the top of the can surrounding the test tube. Leave enough of an opening around the test tube so that the thermometer can be read.

12. Put on safety glasses. Be sure the metal pan is below the calorimeter and lined with aluminum foil and then carefully ignite the plant material. Continue to observe the temperature until the plant material is all burned. Record in the table the highest temperature that the water reached.

13. Calculate the total amount of heat energy given off by your plant using the formula:

Heat in calories = mass of water (grams) x $(T_2 - T_1)$

1ml of water = 1 gram of water
T_2 = final temperature
T_1 = initial temperature

DATA TABLE

1. MASS OF THE PLANT _____ GRAMS.
2. MASS OF THE WATER _____ GRAMS.
3. INITIAL TEMPERATURE READING (T_1) = _____ ^oC.
4. FINAL TEMPERATURE READING (T_2) = _____ ^oC.

HEAT IN CALORIES = MASS OF WATER(GRAMS) X $(T_2 - T_1)$

LOOKING BACK

As our need for energy increases new energy sources must be found. Plants may provide us with one small answer, for they are able to provide us with heat energy. This activity demonstrated that it is possible to trap the sun's energy in a relatively short period of time and then release it.

QUESTIONS

1. What was the total amount of heat energy in calories released by your plant?

2. If watt hours = $\frac{\text{heat in calories} \times 1.16}{1000}$, determine how many watt hours of energy your plant released.

3. A 100 watt bulb uses 100 watts in 1 hour of burning. Could your plant keep a light bulb lit for 1 hour? Explain your answer.

GOING FURTHER

- From the results obtained in your activity, find out how much of your plant that you would have to burn to provide the equivalent of one gallon of gasoline.

  1000 watt hours = 1 kilowatt hour
  1 gallon of gasoline = 3,615 kilowatt hours of available energy

- Determine if there are other kinds of plants that store more efficiently.

Teacher Information Sheet

BEANLIGHT

Suggested Grade Level and Discipline

9th Science
Biology, Physics, General Science

Background Information

Our country is presently experiencing an energy crisis. Simply stated, we are using more energy than our nation can derive from its fossil fuel resources. In order to meet our present and future energy needs we must import large amounts of fossil fuels (oil and natural gas). We are faced with the difficult fact that the foreign supply could be cut off at any time and the knowledge that finite amounts of fossil fuels exist. At the present rate of consumption, scientists estimate that our nation will have used up its entire supply of oil and gas by the year 2000.

With this background information in mind, we must clearly find and use alternative energy sources. Among the sources presently being discussed are: capturing solar energy by means of solar collectors, harnessing wind energy, developing geothermal energy, harnessing the power of seas and tides. All of these energy sources ultimately come from the sun. Although all of these methods sound new and exotic, they have been used by man, or at least, been known about, for many years.

The ignition of plant material as a source of energy to run modern technology is within the realm of possibilities. This exercise points out how quickly solar energy is incorporated into plants. The importance of this becomes apparent when one realizes how long a period of time it takes to form fossil fuel and how quickly it is used.

In this activity your students will measure the amount of heat energy that a plant can release when burned. The units used will be calories, and will be determined using the formula.

Heat in calories = mass of water(grams) x $(T_2 - T_1)$
T_2 = the final temperature in ^{o}Celsius
T_1 = the initial temperature in ^{o}Celsius

It is assumed that the specific heat of water is one when using the formula to calculate the amount of heat produced. To convert the heat in calories to watt hours, use the following equation:

$$\frac{\text{heat in calories} \times 1.16}{1000} = \text{watt hours}$$

It should be noted that the calorimeter does allow for some loss of heat energy. Therefore students should be made aware of the fact that this is only an approximation of the actual heat energy released.

Hints on Gathering Materials

- Prior to the start of the activity, have students collect and cut milk cartons for planting.
- Prior to this lab, collect metal cans having a diameter of about 8cm. Coffee cans work well.
- Prior to this activity, ask for student volunteers to help build the calorimeter.

Suggested Time Allotment

- One class period to plant beans and position them.
- One month to grow plants.
- One week to dry plants.
- One class period for burning plants and recording data.
- One class period to summarize calculations and results and discuss the conversion of the sun's energy to the heat energy released by plants.

Suggested Approach

- Have students work in groups in the planting and growing of the beans.
- Have students work in groups in the drying of the plant material.
- Have students work in groups in burning the plant material in the calorimeter.
- Set up the calorimeter as indicated:

  1. Remove the top and bottom from a metal can.
  2. About 2cm from the bottom of the can insert 4 pieces of wire so that they almost intersect at the center of the can, The plant material will go in here.

3. Attach a clamp to the ringstand and to a large test tube. The test tube should extend down into the calorimeter can.

4. Place the aluminum foil over the top of the can, around the test tube. Leave an opening large enough so that the thermometer can be read. Now put the thermometer in the test tube.

5. Place the can on the ring of the ringstand and place this near the table with a metal pan beneath to catch the burning ash. The pan should be lined with aluminum foil to reflect the heat back.

Typical Results

- Mass of dried plant material = 2.2 grams (Swedish Ivy was used).
- Mass of the water = 10 grams.
- Initial temerperature reading = $23^{o}C$.
- Final temperature reading = $45^{o}C$
- Heat in calories = mass of water(grams) $(T_2 - T_1)$

  Heat in calories = 10 grams $(45^{o}C - 23^{o}C)$

  Heat in calories = 220 calories

Precautions

- *Try this activity in advance of students.*
- *Make sure the burning of the plants is performed under a hood or near a high draw ventilator. The smoke could be a serious problem.*
- *When the plant is removed from the soil and washed, it should be wrapped in a "twist log" form and allowed to dry.*
- *Be very careful in burning the plant material. Make sure the calorimeter is secure on the ringstand.*
- *Wear protective eye glasses during the burning.*

Modifications

- Try measuring the amount of heat energy released by a variety of plants to determine which grows fastest and produces the greatest amounts of heat energy.
- Since so much smoke is produced, you may wish to do it as a teacher demonstration.

Evaluation

- Check the student data, as well as the answers to the questions.

References

- *Solar Energy Lab Experiments Book*, Thomas Norton, (Emmaus, Penn.: Rodale Press), 1977.

BIOMASS — STORED SOLAR ENERGY

INTRODUCTION

Solar energy can be stored, and nature has provided us with many solar collector systems that do just that. Did you pass any on your way to school today? Was the collector collecting, or was it taking a break until spring? During their growing season, trees collect solar energy and store it as chemical energy. They accomplish this task by means of the process of photosynthesis, during which the plants capture light energy and use it to change water and carbon dioxide into oxygen and carbohydrates. Plants then use the carbohydrates as a source of energy for their own growth. As plants increase in size their biomass becomes a potential source of fuel for heating homes.

This activity will give you information about the heat content of wood and the traditional method of measuring quantities of wood in cords. This activity will also enable you to compare the cost of using wood for heat to the cost of using an equivalent amount of oil, coal, natural gas and electricity.

OBJECTIVES

At the completion of this activity, you should be able to:

- o compute the cord measure of wood if it is neatly stacked in a pile forming a rectangular solid.
- o compute the amount of wood required to heat your home if you know the amount of coal or oil required for this task.
- o compare the cost/million BTU of various types of wood.
- o compare the cost/BTU of wood with coal or oil.

SKILLS AND KNOWLEDGE YOU NEED

- How to compute the volume of a rectangular solid.
- How to compute or compare ratios.

MATERIALS

- Chart of heat contents of various woods.

METHOD

1. Compute a full cord measure of wood:

   a) Compute the volume of wood to be measured, e.g., a pile $7' \times 8' \times 8' = V = l \times w \times h = 7' \times 8' \times 8' = 448\ ft^3$

   b) Since 1 full cord = $4' \times 4' \times 8'$, 1 cord = $128\ ft^3$
   Divide the volume of the wood by 128 ft and obtain the cord.

   i.e., $\frac{448\ ft^3}{128\ ft^3/cord} = 3.5$ full cord

   c) Determine the volumes and number of full cords for the sample wood listed in table 1.

2. Compute the available heat per pound for various types of wood, and compare the cost/million BTU for each type of wood as given in table 2.

   a) Divide the available heat per cord in BTU's/cord by the weight per full cord in pounds. This will give the available heat per pound in BTU/lb.

b) Assume a cost per full cord for all types of wood to be $100. Compute the cost/million BTU by dividing the cost per full cord by the available heat per cord in million BTU's per full cord.

3. Assuming that 1 full cord of hardwood is equivalent in heat content to 200 gallons of oil, 1 ton of hard coal, 29,000 ft^3 of natural gas, or 8,400 WKH of electricity, compare the cost of the fuels.

4. Knowing the amount of fuel or electricity required to heat your home for a year, you should compute the amount of wood in full cords that you would need.

LOOKING BACK

Trees and other vegetation collect solar energy and store it. You should have noted that most species of wood contain essentially the same available energy per pound but they vary significantly in density. This means the more dense woods are a better buy if sold by volumetric measure such as cords. Perhaps wood should be sold by weight or mass measure.

QUESTIONS

1. If one had to buy wood in your area, would it be cheaper to heat with wood than with oil, coal, natural gas or electricity?

2. What type of wood is the best buy if sold by cord measure?

3. How many cords of wood would you need in order to heat your home?

GOING FURTHER

- Identify woodlots in your area where wood for fuel is available.
- What are some of the problems that you might experience in using wood as fuel for heating?
- What are some of the latest investigations being conducted in use of biomass as a future fuel?
- Compute the volume of a full cord in cubic meters.
- Using the data provided in table 2, determine the available heat per full cord in kilocalories.
- Determine the densities of various types of woods.

WORK SHEET

DETERMINATION OF CORDS

TABLE 1

WOOD SAMPLE	LENGTH FT	WIDTH FT	HEIGHT FT	VOLUME (FT^3)	CORD
A	3	5	6		
B	3	6	2		
C	15	12	7		
D	6"	4"	15"		
E	7	9	3		
F	14	12	6		

HEATING VALUE OF WOOD

TABLE 2

TYPE OF WOOD	WEIGHT/CORD (AIR DRIED) LBS/CORD	AVAILABLE HEAT/FULL CORD MILLION BTU	AVAILABLE HEAT LB. BTU	COST/MILLION BTU AT $100/FULL CORD
ASH	3400	20.0		
ASPEN	2160	12.5		
BEECH	3760	21.8		
BIRCH	3680	21.3		
DOUGLAS FIR	2400	18.0		
ELM	2900	17.2		
HICKORY	4240	24.6		
MAPLE	3200	18.6		
RED OAK	3680	21.3		
WHITE OAK	3920	22.7		
PINE (WHITE)	2080	13.5		

Teacher Information Sheet

BIOMASS - STORED SOLAR ENERGY

Suggested Grade Level and Discipline

10-12th Grade Science

Background Information

Wood, a fuel which was common to our forefathers, has once again become a viable source of energy for heating homes. This form of energy is stored solar energy, and this concept should be stressed with students.

It is estimated that the sun falling on land fixes and reduces about 16×10^9 tons of carbon per year. Only 3.5×10^9 tons of coal were mined worldwide in 1970. Apparently, the potential of biofuel is four times the coal resources mined each year. (It should be noted however, that if we burned this much biomass, we would have none left for food, wood, fiber, etc.)

Wood, one of the most popular fuels, has many advantages as a fuel. It is storable without a container, portable, safe to handle, and burns relatively cleanly. A cord (4' x 4' x 8') is by definition 128 $ft.^3$ of wood neatly stacked. Actually, a cord contains approximately 80 $ft.^3$ of wood; the remainder of the volume is air. A cord of wood is approximately equal to a ton of coal, or 200 gallons of fuel oil, or 2,900 cubic feet of natural gas or 8,400 KWH of electricity. A face cord or stove cord is typically 16" - 18" x 4' x 8' and is approximately 1/3 of a full cord.

All species of wood contain essentially the same amount of heat/lb. but they differ greatly in densities. When comparing heat contents per cord of wood, you will find differing values in various charts. This is due to the percentage of water contained in the wood more than anything else. The more water the wood contains, the less the heat output, because much of the energy goes into vaporizing this water. The table shown under Typical Results lists wood commonly used for fuel and the heat content/cord. Some time could be spent comparing densities per cord or perhaps comparing costs/BTU of one species of wood against another. It is traditional that wood be sold by the cord, and typically the cost per cord is the same for different kinds of wood, yet students should be made aware of the fact that a dense hardwood yields significantly greater heat than softwoods or less dense hardwoods such as willow, poplar etc.

It should be noted that the heat can be extracted from the wood by fairly complete combustion. This means sufficient oxygen and high temperatures, conditions one can achieve with dry wood in a fireplace, Franklin stove, or any stove which allows a large amount of air into the stove. However, most of this heat will go up the chimney, and the homeowner will not benefit much from this. As to the heat flow up the chimney, a partial vacuum is created in the house, and the warm air of the house (which has gone up the chimney) is replaced by cold air which is drawn in around windows and doors. This is an important concept that many overlook, and it is the reason why fireplaces and inefficient woodstoves often yield a net heat loss to a house even though it is hot in the room where the device is in operation. The other way to accomplish more complete combustion is to have a stove which is "airtight," i.e., it allows very little air to enter the stove. If this type of stove has a

secondary combustion chamber, the volatiles released from the wood will recycle inside the stove and will pick up enough energy until they too become oxidized. Some of these new woodstoves with secondary combustion operate at 70-80% efficiency, they do not use much air from the house, and they are therefore very effective heaters. It should be noted that efficiency is output/input; so, if the efficiency of a good woodstove is 75% and an inefficient stove such as the Franklin stove is 15%, (with doors closed) the efficient airtight stove will use only 1/5 the amount of wood that the Franklin stove would use to accomplish the same amount of heating. A simple cost analysis will show that an efficient stove will often pay for itself in one year because of its low fuel consumption. Environmentally, the significance is tremendous also.

Teachers will find that students will readily discuss this information with their parents if they have stoves or fireplaces, or if they live in a house which is cold and uncomfortable.

To tie this in with solar energy, a good discussion could be held on how the densities (and therefore heat content) of the wood depend upon the life of the tree, the length of growing season, etc. which are functions of the amount of solar energy which is "captured" and stored.

Suggested Time Allotment

- One class period (50 minutes).
- One day if supplementary activity of measuring density is used.

Suggested Approach

- Cover this topic during the heating season. Students living in cold houses, or students who use wood heat, will be genuinely interested in this topic.
- Before this activity, ask students to find out how much oil, coal, natural gas or electricity they use in a year in order to heat their homes.
- Ask students how much wood it would take to totally heat their house. This should lead into a discussion of cord measure of wood and finally, into heat content. Have the students determine how large a woodlot is necessary to provide this much energy on a yearly basis.
- Have students compute the heat content/lb. from the heat content/cord.
- Using the going rate for wood in your area, (be sure you compare full cord prices and not face cord prices), compare the cost/BTU for wood, coal, oil, natural gas and electricity.
- Be certain to point out the ecological implications of using wood wastes and managed woodlots rather than fossil fuels which are rapidly being depleted.
- Discuss the importance of using certain kinds of stoves in order to retain the heat in the house so it does not escape.

Typical Results

HEATING VALUE OF WOOD
TABLE 2

TYPE OF WOOD	WEIGHT/CORD (AIR DRIED) LBS/CORD	AVAILABLE HEAT/CORD MILLION BTU	AVAILABLE HEAT/LB. BTU	COST/MILLION BTU AT $100/CORD
ASH	3400	20.0	5814	$5.00
ASPEN	2160	12.5	5787	8.00
BEECH	3760	21.8	5798	4.59
BIRCH	3680	21.3	5788	4.69
DOUGLAS FIR	2400	18.0	7500	[illegible]56
ELM	2900	17.2	5931	5.81
HICKORY	4240	24.6	5801	4.07
MAPLE	3200	18.6	5813	5.38
RED OAK	3680	21.3	5788	4.69
WHITE OAK	3920	22.7	5791	4.40
PINE (WHITE)	2080	13.3	6394	7.52

Evaluation

- Check the data table calculations and the questions.

FUELS FROM SOLAR ENERGY AND WASTES

INTRODUCTION

In 1973 the municipal waste per person per day was 7.7 kilograms. This amounts to about 123 million metric tons of solid waste. The collection and disposal of urban waste cost about $3.5 billion dollars. Much of the waste is combustible. As a result, many cities are beginning to use their trash to heat buildings. In some instances their wastes are being changed to fuels such as oil and natural gas.

One method of converting wastes is known as pyrolysis, in which heat is used to decompose the waste. In this activity you will change wastes into fuels.

OBJECTIVES

At the completion of this activity, you should be able to:

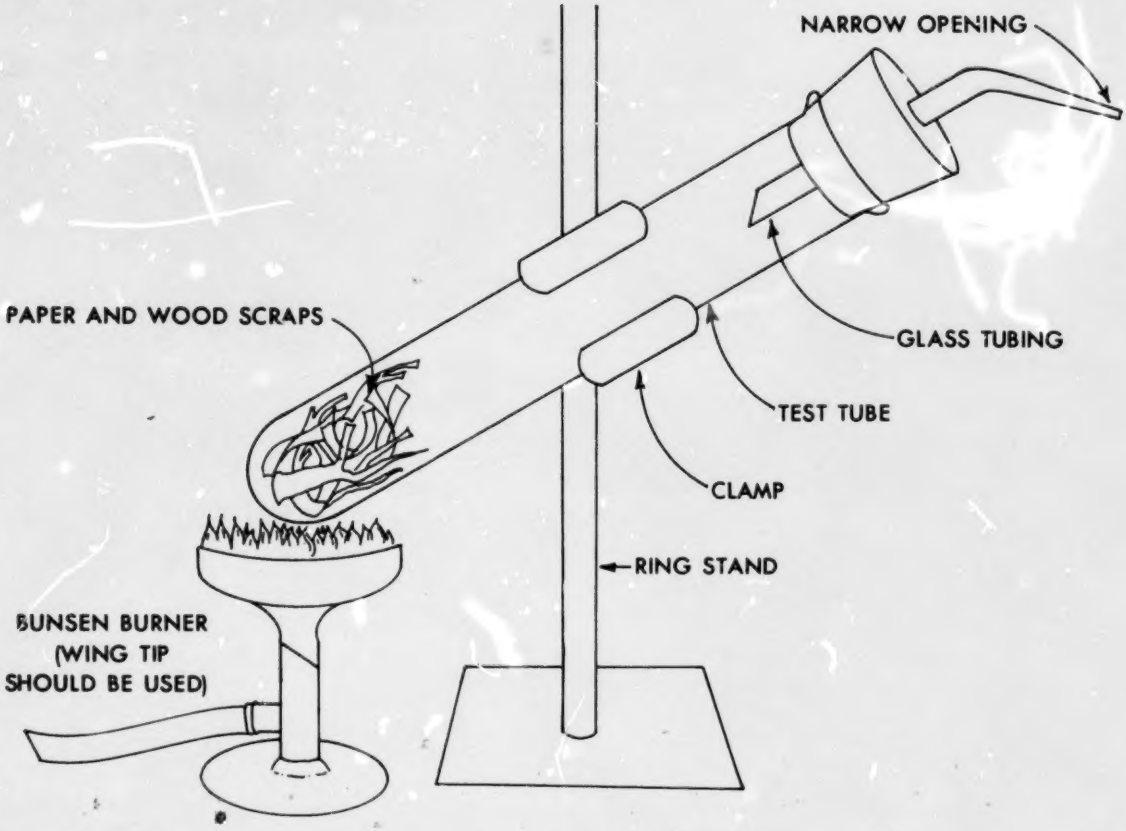
- o locate the focal point for a concentrating len.
- o build a pyrolytic converter which can change combustible waste into three kinds of fuel.

SKILLS AND KNOWLEDGE YOU NEED

- How to follow instructions in setting up an experiment.

MATERIALS

- Convex lens.
- Fresnel lens.
- Reflecting devices, such as concave mirrors, parabolic reflectors, or curved aluminum foil.
- Heat lamp.
- 100 watt bulb.
- Bunsen burner.
- Ringstand and clamp.
- Glass tubing, one-hole rubber stopper, and a test tube between 15cm and 20cm.
- Wood splints.
- Matches.
- Trash, such as paper, ice cream sticks, potato peels, paper bags, or grass clippings.



METHOD

1. Obtain the set up for the pyrolytic converter. Place a small quantity of paper scraps and small chunks of wood in the test tube.

2. After your teacher has approved your set up, begin to heat the test tube using a bunsen burner with a wing tip. Be sure to wear safety glasses.

3. Place a burning wood splint at the opening of the glass tubing where the gases are escaping. Describe what happens.

4. Observe the residue in the test tube. Describe what you see.

5. What does the solid material look like? Describe it.

6. As an assignment, develop a simple device that could use concentrated sunlight to convert wastes into fuels.

LOOKING BACK

It has been determined that the energy potential from waste in 1973 was equivalent to 150 million barrels of oil. This represents a tremendous source of fuels. By using the cheap energy from the sun to convert trash into fuel, a great savings not only in fuel consumption but also in the cost of disposing of the trash can be realized.

QUESTIONS

1. What is meant by pyrolysis?
2. Why would lenses and reflectors be beneficial to use if solar energy were utilized in the pyrolytic conversion of waste into fuel?
3. Try to find out what three fuels were produced in the pyrolytic converter.

GOING FURTHER

- Write to large municipalities asking them for literature on their plans or present operations with pyrolytic converters.
- Which sunlight concentrators, lenses or reflectors do you think would be most practical in solar energy converters?
- Determine which wastes produce the best fuels.

Teacher Information Sheet

FUELS FROM SOLAR ENERGY AND WASTES

Suggested Grade Level and Discipline

9th Grade Science
Biology
General Science and Environmental Science

Background Information

In the 70's, the cost of collecting and disposing of urban waste has been in the neighborhood of about 3 to 4 billion dollars a year. Of this waste about 80% is combustible. The potential energy in these wastes is tremendous. In the mid 70's, municipal wastes had the energy potential of 150 million barrels of oil in one year. If we add all the other wastes in this country; industrial, agricultural, etc., the energy potential should be much greater. The expected organic waste in the United States for the year 1980 (millions of metric tons, dry weight) is:

Urban refuse	202
Manure	205
Agriculture	355
Industrial	45
Municipal sewage	13
Other	55

Pyrolysis is the chemical decomposition of waste in the absence of oxygen. Materials are heated in the absence of air at atmospheric pressure, and several products are produced: gas, char (partially burned carbon residue), and heavy tar-like oil. All three of these products can be used as fuels. To provide the heat source to run a pyrolytic converter, sunlight as well as other energy sources could be used. In order to achieve sufficient temperatures for the chemical decompostion of wastes using the sun, lenses and reflecting mirrors which concentrate light energy will be needed.

In this activity students will observe the effectiveness of lenses and mirrors in concentrating light and heat. They will also witness a working pyrolytic converter. The heat source, however, will be a bunsen burner.

Hints on Gathering Materials

- All the materials should be available in most science rooms.

Suggested Time Allotment

This activity can be done in 3 forty-five minute class periods; one period as an introduction, one to do the experiment, and one to discuss the results.

Suggested Approach

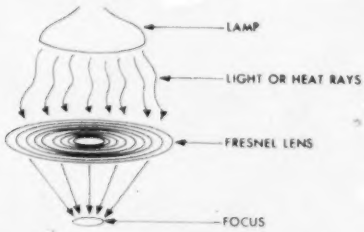
- Gather the apparatus and have it set up in advance of the activity.

- Use the first day as a demonstration and discussion time, as shown.

- You may conduct this activity as a demonstration, if it is not convenient to use with the whole class.

- Briefly discuss the energy in sunlight. Show by means of a simple diagram that the visible light in sunlight, when absorbed, produces heat energy.

- Demonstrate how a Fresnel lens concentrates light or heat rays. You may use a student to assist you in locating the focal point. Briefly discuss how the concentrated rays produce a higher temperature at the focal point.



- Place a match (or thermocouple) at the focal point of the Fresnel lens. Replace the 100W bulb with a heat lamp. The high temperature at the focal point should cause the match to ignite within a few minutes. If conditions permit, use direct sunlight as the energy source, since results are faster and more dramatic. Caution: When using the Fresnel lens keep combustible materials out of the focusing area. When not in use, cover the lens with an opaque material.

- Demonstrate various curved reflectors to show that they can be used as light, or heat concentrators.

- Have students suggest how concentrated sunlight could be used as a heat source for the decomposition of wastes. Remind them that the present state of the technology involves the heating of wastes with fossil fuels. The use of sunlight, then, could greatly reduce, or eliminate, the need for fossil fuels.

- Show the students the demonstration apparatus for the decomposition of trash. Tell them that a bunsen burner flame will be substituted for the concentrated sunlight.

- On the second day of this activity students should perform the experiment.

- Assign students to develop a simple device that could use concentrated sunlight to convert wastes into fuels. The diagram should have a solar collector(s) concentrating light on a closed tank.

- On the third day discuss the various designs and the problems associated with technology of using sunlight as a heat source for waste conversion. There should include: costs, separation and shipment of trash, location, and available sunlight.

Typical Results

- The gases escaping from the glass tube should ignite when a flame is brought near them.

- There should be a liquid residue inside the test tube.

- Char (charcoal) should also remain in the tube.

Precautions

- *Do this activity prior to the class. If you feel uncomfortable with having students do this, then do it as a demonstration.*

- *Since smoke may be produced have the room well-ventilated. If possible a fan should be used to assist in the removal of the smoke from the room.*

- *When using the Fresnel lens, keep conbustible materials out of the focusing area. When these lenses are nit in use, cover them with an opaque material.*

- *All students should wear safety glasses when conducting the lab.*

Modifications

- The Fresnel lens, or a similar device, may be used to decompose wastes in a container. This activity could be done outdoors.

Evaluation

- Check students' answers to the questions.

- Check students' designs of a solar powered pyrolytic converter.

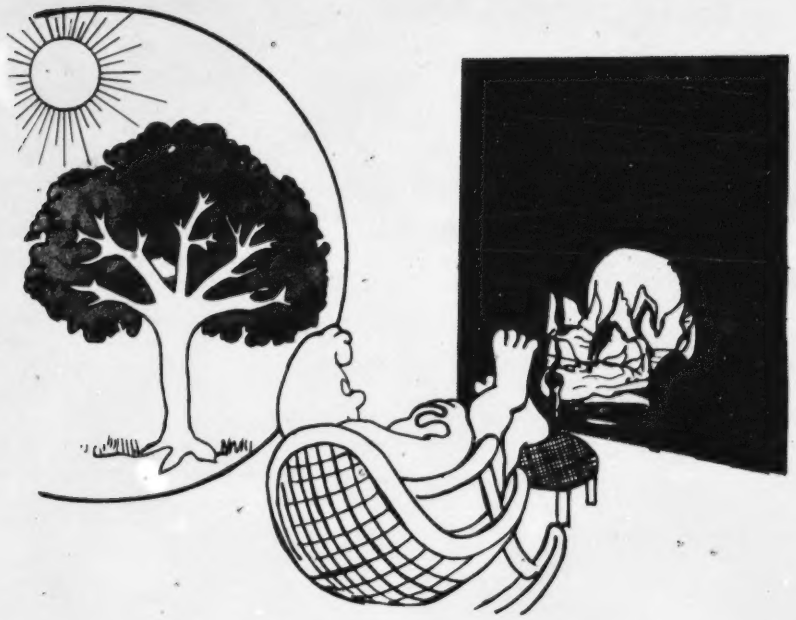
References

Fuels From Wastes: Bioconversion, National Science Teachers Association, ERDA, Technical Information Center, Oak Ridge, Tennessee.

Solar Energy Experiments, Thomas Norton, (Emmaus, Penn.: Rodale Press, Inc.), 1977.

DRAFT - ACTIVITY 29

YOUR PLACE IN THE SUN



INTRODUCTION

The sun provides the earth with nearly all of the energy that man uses. Plants can store this energy so that we can use it at night or when the sun is hidden by clouds. Photosynthesis is the word used to describe the process of turning sunlight into plant material. Scientists call the use of plant material to produce energy "biomass".

OBJECTIVES

At the completion of this activity, you should be able to:

- o estimate the basic amount of energy that your family needs in a year.
- o estimate the amount of land that your family would need in order to grow its own energy in the form of biomass.

SKILLS AND KNOWLEDGE YOU NEED

- How to add, multiply and divide decimal numbers.
- How to find information about your family's home, appliances, and car.

MATERIALS

- Table of Energy Use.

METHOD

1. Look over the Table of Energy Use. Notice that it is divided into four sections: heating, appliances, food, and transportation.
2. Use this table to complete the Energy Use Worksheet as it applies to your family. (These basic requirements assume that nothing new can be bought, such as a new TV or new clothes. New products require much more energy.)
3. After you have added the entries in the Energy Use Worksheet, you will have the total amount of energy your family needs in one year. (Remember, these are bare minimums.)
4. It has been estimated that one square foot (1 ft^2) of land area can produce approximately 700 BTU of energy in one year. You can now calculate the amount of land your family would need to supply its energy needs. Divide the number of BTU's by 700.

EXAMPLE:

$$\begin{array}{r|l} & 628{,}571.\ FT^2 \\ \hline 700 & 440{,}000{,}000\ BTU's \end{array}$$

(FAMILY NEEDS)

LOOKING BACK

You should be able to give the amount of energy in BTU's that your family uses in a year. From this you have calculated the amount of land that would be necessary to supply the energy from biomass - using solar energy through the process of photosynthesis. Remember that this is your basic energy need. Your family can't buy a new car or even repair the old one with this amount of energy. No new snowmobiles or skateboards either. Making these new items requires a tremendous amount of energy, much more than your family uses.

Energy Use Worksheet

ENERGY USE	ENERGY USED IN MILLIONS OF BTU PER YEAR
1. HEATING YOUR HOME	_____
2. OPERATING YOUR APPLIANCES	

NAME OF APPLIANCE	ENERGY USED IN MILLIONS OF BTU PER YEAR
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
TOTAL ENERGY USED FOR APPLIANCES	_____

3. FOOD FOR THE MEMBERS OF YOUR FAMILY	_____
4. TRANSPORTATION	_____
TOTAL ENERGY USED FOR HEATING, APPLIANCES, FOOD AND TRANSPORTATION IN MILLIONS OF BTU/YR.	_____

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Table of Energy Use

1. HEATING

large house (4 bedrooms)	168 million BTU/yr.
medium house (2 bedrooms)	140 million BTU/yr.
small house or mobile home	112 million BTU/yr.

2. APPLIANCES

Note: These figures are for EACH appliance. If you have more than one you must multiply the million BTU/yr. for each appliance by the number of appliances you have. For example, one freezer uses 4.1 million BTU/yr. Two freezers use 2 times 4.1 million BTU/yr. or 8.2 million BTU/yr.

	Million BTU/yr.		Million BTU/yr.
Lighting	3.3	TV (color)	
Hot water	14.0	tube type	2.3
Stove	4.	solid state	.4
Clothes dryer	3.4	Automatic clothes	
Dishwasher	1.2	washer	.3
Furnace fan	2.	Electric blanket	.7
Oil burner	1.3	Dehumidifier	1.3
Freezer	4.1	Portable electric	
Refrigerator	2.5	heater	.9
Water pump	.7	Radio	.3
TV (black and white)		Stereo	.4
tube type	1.2	Iron	.5
solid state	.4	Microwave oven	.7

3. FOOD

For each member of your family = .4 million BTU/yr. (A family of four would need 4 times .4 million BTU/yr. or 1.6 million BTU/yr.)

4. TRANSPORTATION

This section assumes that your family owns and drives at least one car. If your family does not own or drive a car, skip this section.

To use the table you will need to know: 1) approximately how far your family drives in one year and 2) the number of miles your car gets per gallon of gasoline. You can use the following approximations if you are not sure. In a family where one parent drives to work 20 miles one way, the yearly mileage is probably 15,000 miles. If both parents drive to work at different places, the yearly mileage is close to 20,000.

For the number of miles for each gallon of gasoline, you can use the following approximations if you do not know the actual figures.

Subcompact car	30 mpg
Compact car	20 mpg
Large car	15 mpg
Pick up trucks	10 mpg

Now use the following table to find the number of millions of BTU/yr. that your family uses for transportation.

MILES PER GALLON (mpg)

MILES DRIVEN PER/YR.	5	10	15	20	25	30
5,000	130	65	43	33	26	22
10,000	260	130	86	65	52	43
15,000	390	195	129	98	78	65
20,000	520	260	173	130	104	87
25,000	650	325	215	163	130	103

(MILLIONS OF BTU PER YEAR)

QUESTIONS

1. What does your family use the most energy for in one year? the least energy?

2. Does your family own or rent enough land to supply its energy needs? HINT: You need to know how much land your family owns or rents. If you know the size of your lot in feet, multiply the length times the width to get the number of square feet. For example, a 100 ft by 100 ft lot would have 10,000 square feet. If you have a large amount of land and you know the number of acres in it, you can use the fact that there are about 44,000 square feet in one acre.

GOING FURTHER

A. This activity gives you only a rough idea of the amount of energy your family uses in a year. You can get a much better picture of your family's energy needs if you can get accurate figures for the amount of fuel oil, gasoline, natural gas and electricity your family uses in a year. See your teacher for directions.

B. The population of the world is estimated to be 4,500 (four and a half billion). How much land would be needed to supply energy for all these people? HINT: You must find the average amount of energy each person in your family uses. The total area of the earth is 78,100,000,000,000 ft^2. Is there enough room to supply energy for the whole world through biomass?

C. It would be possible to calculate more exact energy use figures from an analysis of actual home energy use figures such as the number of cubic feet of natural gas used, the number of gallons of fuel oil used, the number of gallons of gasoline used, and the number of kilowatt hours of electricity used. Factors for converting such units to BTU's are listed below:

1 gallon of fuel oil = 145,000 BTU

1000 ft^3 of natural gas = 1,031,000 BTU

1 gallon of gasoline = 125,000 BTU

1 kilowatt hour of electricity = 3,413 BTU

1 pound bottled gas = 21,700 BTU

Teacher Information Sheet

YOUR PLACE IN THE SUN

Suggested Grade Level and Discipline

9-12 Science (Some lower grades)
Life Science
Home Economics
Industrial Art

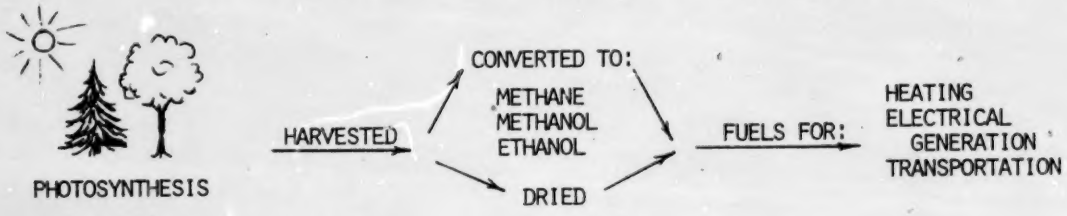
(Designed primarily for students in suburban and rural areas, but may be adapted for use by urban students.)

Background Information

The term "biomass" refers to an amount of plant material in which solar energy has been stored through photosynthesis. It has been estimated that from 0.1 to 1% of the solar energy falling on an area can be stored as chemical energy by photosynthesis.

For many years, man made use of biomass by using wood to cook his food and to heat his shelters. Even fossil fuels such as coal, oil, and natural gas can be thought of as vast stores of biomasses which took millions of years to be formed. In these days of dwindling fossil fuel supplies, man is looking again at biomass as a form of energy to be tapped. Wood is becoming increasingly important as a fuel source. Some scientists have suggested that fast growing plants such as kelp could be grown, dried, and burned as fuel for producing heat and electricity.

This chart shows how biomass could help deal with energy needs.



Hints on Gathering Materials

- Each student should have a copy of the student activity sheet, including the Energy Use Worksheet and the Table of Energy Use.

Suggested Time Allotment

- Give the students one week to complete the home energy survey. Two 45 minute class periods will be necessary to complete the calculations and to have a follow-up discussion.

Suggested Approach

Biological Approach - The activity will articulate well with the study of photosynthesis during a unit on plants or ecology.

Independent Approach - Though this activity can be done independently, it would be wise for the teacher to introduce the activity and to cover the following points with the students.

1. Photosynthesis is the primary process of storing solar energy.

2. The term "biomass" is simply a new term for a old concept - energy storage and use in plants.

3. A BTU is a unit of energy. Do not dwell on the meaning of the term. BTU is used solely for convenience; it is not the purpose of this activity to teach students to define or interpret the BTU. Tell students that using the BTU will allow us to put all energy use into the same terms for calculating a family's energy use.

4. Emphasize the meaning of the results. Students tend to become very involved in the calculations and to lose sight of the objective of the activity -- to find the land necessary to support the energy needs of his family.

   NOTE: Some students have great difficulty with the math involved. If this seems to be getting in the way of the student's reaching the objectives, you might encourage the use of calculators. If possible, however, offer to help the students individually with the calculations. This will have the added benefit of aiding the students' math ability.

Interdisciplinary Approach - Math teachers may find that they are able to use the activity to reinforce work with decimals and division involving large numbers. If students are sufficiently prepared, scientific notation can be used to do the calculations.

During the discussion of the activity, the teacher can point out career opportunities available in fields related to the use and production of plants for energy. As this field is explored many career opportunities will become available which are now only speculation.

Consumer education is an intergral part of this activity. It can be used as a starting point for a discussion of using wood for fuel in the home, of the most economical way of using wood, and of its comparisons with other fuels such as oil and natural gas.

Typical Results

- As you can see by working through the Energy Use Worksheet, most students' total energy needs will fall between 140 million and 560 million BTU per year. Therefore, the land area necessary to provide this amount of energy per year should be between 200,000 ft^2 and 800,000 ft^2.

Evaluation

- Check students' data table and answers to the questions.
- Check to see that students correctly calculated the amount of land required to maintain their present energy needs.

References

- *Fuels from Plants Bioconversion,* John and Kathryn Fowler, National Science Teachers Association Fact Sheet.
- *The Flow of Energy in a Forest Ecosystem,* James R. Gosz, Richard T. Holmes, Gene E. Likens, and F. Herbert Bormann, Scientific America, March, 1978, pp. 92-102.

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